Survival estimates for demersal reef fishes released by anglers

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ABSTRACT

Reef fish were caught with hook-and-line in three depth zones, 21 m, 36 m, and 46-54 m, off central South Carolina. Upon capture, fish were immediately placed in a 1 m^3 tank with flowthrough seawater and tallied by species as "swam" (able to reach the bottom of the tank, and therefore possible survivors) or "floated" (probable mortalities). Fish that floated were discarded, while those that swam were placed in weighted cylindrical cages of plastic mesh. Cages were deployed immediately and remained on the bottom for approximately 24 hours. After cages were retrieved, fish were recorded as alive or dead. In the shallower depth zones the conditions of fish in most cages were recorded by scuba divers just before cage retrieval for comparison to observations made at the surface. Additional swam vs. floated data were gathered by observing fish after release overboard in order to determine if behavior at the sea surface was similar to that in the tank.

Ability to swim downward was evaluated in the tank for 875 individuals of nineteen species and at the sea surface for 637 individuals of seventeen species, and 606 individuals of sixteen species were held in cages for approximately 24 hours. The two methods of evaluating swimming ability produced similar results for all species except black sea bass; the tank method tended to over-estimate the percent of black sea bass able to swim downward. Survival, both in terms of ability to swim downward and to survive for 24 hours, varies between species and appears to be inversely related except to captive depth. Overall survival estimates for all species pooled were approximately 88% at 21 m, 81% at 36 m, and 62% at 46-54 m.

KEY WORDS: angler, mortality, reef fish, release, survival.

INTRODUCTION

Demersal reef fishes in the South Atlantic Bight are harvested with hook-and-line by commercial fishermen, recreational fishermen in private boats, and headboats. Most species are probably fully exploited if not overfished (Huntsman *et al.*, 1983; Collins and Sedberry, 1991). Certain management options (e.g. creel limits and minimum size regulations) suggested for the fishery assume the survival of released fish is high. However, capture by anglers results in rapid decompression, sometimes causing fish to exhibit stomach and intestinal eversion, protruding eyes, bubbles under the skin, and the inability to resubmerge upon release (Rogers *et al.*,1986; unpublished data).

Some of these injuries are probably fatal. Waters and Huntsman (1986) modified a yield-per-recruit model to include catch-and release mortality, and they described the implications for fishery management. However, application of this model requires estimates of actual survival probabilities.

Estimates of catch-and release mortality have been reported for a few species of centrarchids (Feathers and Knable, 1983), percichthyids (Harrell, 1987), and salmonids (Warner, 1978; Dotson, 1982; Loftus *et al.*, 1988). However, catch-and release mortality for reef fishes has not been rigorously evaluated. Parker (1985) and Gitschlag and Renaud (in press) reported on the ability of red snapper, *Lutjanus campechanus*, to swim downward after capture and on survival of this species in cages, but no information exists on survival of other important reef species. This report summarizes the data resulting from an effort to estimate the survival of several reef species through the first day following capture and release.

METHODS

In summer during 1988, 1990, and 1991 reef fish were first captured with hook-and-line in depths of 21 m, 36 m, and 46-54 m off central South Carolina (USA). Anglers fished with relatively heavy tackle similar to that commonly used on some headboats and commercial fishing boats (Penn Senator 6/0 reels, 23 kg test monofilament line, and 1.8 m rods). Terminal tackle consisted of three 4/0 hooks 0.5 m apart above a 0.45 kg weight, and bait was a variety of cut fishes and squid. Target species were reef fishes that are commercially harvested or are commonly retained by headboat anglers. No special treatment was provided to fish during the capture process.

Upon capture, fish were immediately placed in a 1 m^3 tank with flow-through seawater. Fish condition was recorded as "swam" (able to swim down to the bottom of the tank, and therefore potential survivors) or "floated" (probable mortalities). Fish that floated were discarded. Those that swam were placed in a cylindrical cage (1.0 m diameter x 0.75 m high) of plastic mesh with openings small enough (2.5 cm sq.) to minimize entrance of potential predators. The cages, which were weighted to ensure they remained upright on the bottom, were deployed immediately and retrieved after approximately 24 hours. Upon retrieval, fish were recorded as alive or dead, and lengths were measured. In the two shallower depth zones the conditions of fish in most cages were also recorded by scuba divers immediately before cage retrieval. The Kolmogorov-Smirnov one sample test for goodness of fit was applied to 5 cm length classes of the most abundant species to determine if greater survival occurred in some length classes. Additional swam vs. floated information was gathered by observing fish after release overboard (for about one minute or until they swam out of sight) in order to determine if swimming behavior after actual release was similar to that observed in the tank.

RESULTS

Ability to swim downward was evaluated in the tank for 875 individuals of nineteen species (Table 1). Serranid made up 52% of the individuals, but 47% were *Centroprista striata* and *C. ocyurus; Mycteroperca* spp. and *Epinephelus* spp. (groupers) made up only 4% and 1%, respectively. Other families represented were Lutjanidae (2 spp., 19%), Sparidae (4 spp., 11%), Haemulidae (2 spp., 16%), Balistidae (2 spp., 1%), and Holocentridae (one individual). Only three species were caught in all three depth zones, and none were represented by enough individuals (*e.g.* fifteen) in all depths to determine depth-related trends in percentages that swam. Of the species-depth categories with at least fifteen individuals, the smallest percentage that swam was 53% for *M. phenax* in 46-54 m, and the greatest percentage that swam was 100% for *Calamus leucosteus* and *Haemulon aurolineatum* in 21 m. Pooling all species in each depth zone, the percentage of fish that swam was greatest (98%) in 21 m, intermediate (91%) in 36 m, and least (82%) in 46-54 m.

A total of 637 individuals of seventeen species was observed after release at the sea surface (Table 2). The same families occurred in nearly the same proportions as in the tank study. Like the tank study, only three species occurred in all depth zones and there were none with at least fifteen individuals in all depths. Of the species-depth categories with fifteen individuals, the minimum percentage that swam was 69% for *C. striata* in 36 m, and the maximum was 100% for the same species in 21 m. *Centropristis striata* was the only species for which the percentage that swam down differed greatly from the tank study. Only 69% of those caught in 36 m swam down after release overboard, while 90% from that depth swam down in the tank. Pooling species, fish that swam comprised the following percentages: 96% in 21 m, 84% in 36 m, and 85% in 46-54 m.

Survival after about 24 hours was determined for 606 individuals (sixteen species), all of which swam down in the tank (Table 3). Mean time at depth was 24.0 hr, 23.1 hr, and 23.8 hr for cages in 21 m, 36 m, and 46-54 m, respectively. Evaluations of fish condition made at depth by scuba divers and at the surface after cage retrieval agreed in all cases. Of the species-depth categories with fifteen individuals, the lowest survival percentage after one day in cages was 65% for *Rhomboplites aurorubens* and *Pagrus pagrus* in the 46-54 m depth zone. The greatset survival percentage was 93% for *C. striata* in 21 m. The Kolmogorov-Smirnov test indicated no significant difference in survival between size classes ($p>.05$) for all species tested (Figures 1-3). Pooling species, percent survival in cages was 90% in 21 m, 89% in 36 m, and 75% in 46-54 m.

Table 1. Number of individuals (n) and percent that swam to the bottom of a 1 m deep tank (% swam), by species and depth zone of capture.

	DEPTH ZONE					
	21 m		36 m		46-54 m	
SPECIES	n	% swam	n	% swam	n	% swam
Centropristis striata	100	99	169	90	4	75
C. ocyurus	11	91	112	91	18	78
Mycteroperca microlepis	10	100	4	100	1	0
M. phenax	0	- -	3	100	17	53
Epinephelus adscensionis	0	- -	0	- -	2	0
E. fulvus	0	- -	0	- -	1	0
E. drummondhayi	0	- -	0	- -	2	100
E. morio	0	- -	1	100	0	- -
Lutjanus campechanus	4	100	0	- -	5	20
Rhomboplites aurorubens	0	- -	7	86	148	84
Pagrus pagrus	0	- -	21	95	23	96
Calamus nodosus	0	- -	1	100	8	75
C. leucosteus	20	100	2	100	0	- -
Diplodus holbrooki	20	80	0	- -	0	- -
Haemulon aurolineatum	17	100	0	- -	114	90
H. plumeri	0	- -	4	- -	2	100
Balistes capriscus	2	100	0	- -	4	75
B. vetula	0	- -	0	- -	3	0
Holocentrus ascensionis	0	- -	0	- -	1	100
TOTAL	195	98 %	327	91 %	535	82 %

DISCUSSION

Evaluation of swimming ability in the 1 m deep tank provided accurate results, in comparison to evaluation after release overboard, for all species except *C. striata*. In general, fish that swam down one to two meters below the sea surface were able to continue downward. However, *C. striata* sometimes swam down two to four meters and then floated back to the surface. Thus, the tank did not provide adequate depth for evaluation of this species. Since the cage trial involved fish that swam in the tank trial, the over-estimation of the percent of *C. striata* that swam may have confounded the results of the cage trial in 36 m for this species.

Ability to swim down after release and survival in cages for 24 hours were inversely related to depth and varied with species. Gitschlag and Renaud (in press) also found reduced survival in greater depths, with 99%, 89% and 64% of *L. campechanus* <30 cm fork length swimming down in depths of 21-24 m,

Table 2. Number of individuals (n) and percent that swam down when released at the sea surface (% swam), by species and depth zone of capture.

	DEPTH ZONE					
	21 m		36 m		46-54 m	
SPECIES	n	% swam	n	% swam	n	% swam
Centropristis striata	42	100	121	69	2	50
C. ocyurus	12	100	79	97	33	76
Mycteroperca microlepis	3	100	1	100	0	- -
M. phenax	0	- -	1	100	4	50
Epinephelus adscensionis	0	- -	0	- -	2	0
E.cruentatus	0	- -	0	- -	1	0
Lutjanus campechanus	0	- -	1	0	0	- -
Rhomboplites aurorubens	0	- -	26	96	121	87
Pagrus pagrus	0	- -	25	96	33	94
Calamus nodosus	0	- -	0	- -	12	92
C. leucosteus	1	100	1	100	0	- -
Diplodus holbrooki	20	80	0	- -	0	- -
Haemulon aurolineatum	14	100	5	100	67	90
H. plumeri	0	- -	1	100	1	100
Balistes capriscus	2	100	0	- -	2	50
B. vetula	0	- -	0	- -	2	50
Holocentrus ascensionis	0	- -	0	- -	2	100
TOTAL	94	96%	261	84%	282	85 %

27-30 m, and 37-40 m, respectively. Unfortunately, in the present study few species were abundant in all depth zones, so it is not possible to demonstrate the effect of depth on swimming ability and survival on a species of a specific basis. Making comparisons of survival between depth zones by pooling species provides a means to illustrate the probable decline of survival with increasing depth, but these values should not be utilized when accuracy is important, such as when formulating species specific management options, due to possible survival differences between species. For example, the percent of total individuals that swam down after release overboard in 36 m was 84%. *Centropristis striata* made up 46% of the total sample in 36 m with 69% swimming down. If no *C. striata* had been caught, the pooled value for 36 m would have been around 95%. Thus, it is highly advisable to consider survival on a species specific basis despite difficulties in obtaining sufficient numbers of some species for trials.

Although generalization is not recommended, a generalization concerning groupers (*Mycteroperca* spp. = *Epinephelus* spp.) is worthwhile reporting due to their desirability in both recreational and commercial fisheries. Only 43% of the

Table 3. Number of individuals (n) and percent survival (% surv) after being caged at depth of capture for approximately 24 hrs, by species and depth zone of capture.

	DEPTH ZONE					
	21 m		36 m		46-54 m	
SPECIES	**n**	**% surv**	**n**	**% surv**	**n**	**% surv**
Centropristis striata	85	93	134	87	0	- -
C. ocyurus	9	100	79	92	13	77
Mycteroperca microlepis	4	50	4	100	0	- -
M. phenax	0	- -	2	100	7	100
Epinephelus drummondhayi	0	- -	0	- -	2	100
E. morio	0	- -	1	100	0	- -
Lutjanus campechanus	3	100	1	0	0	- -
Rhomboplites aurorubens	0	- -	6	100	71	65
Pagrus pagrus	0	- -	12	92	17	65
Calamus nodosus	0	- -	1	100	0	- -
C. leucosteus	1	100	1	100	6	83
Diplodus holbrooki	25	92	1	0	0	- -
Haemulon aurolineatum	11	100	2	100	76	80
H. plumeri	1	100	4	100	0	- -
Balistes capriscus	1	100	0	- -	4	100
Holocentrus ascensionis	0	- -	0	- -	1	100
TOTAL	161	90%	248	89%	197	75%
No. cages	20		27		25	
Mean duration (hrs.)	24.0		23.1		23.8	
Standard deviation	3.2		2.7		1.0	

30 individuals from the 46-54 m depth zone (tank and overboard pooled) swam downward. In the cage trials, however, the only two mortalities of twenty individuals were in the 21 m depth zone. This suggests that groupers that are able to submerge are likely to survive. If deflating the swim bladders prior to release significantly increases the percentage that can swim down, the result may be an increase in overall survival.

Rough estimates of overall survival in each depth zone for each species can be generated by multiplying the percent that swam down by the percent that survived in the cage trial. For the most part these estimates are > 70%, especially in the two shallower depth zones, and in no case wherein the number of individuals was 15 survival was less than 50%. Additional mortality may have occurred if the trials have been extended beyond 24 hours. Parker (1991) reported some mortality through 48 hours for *L. campechanus*, although

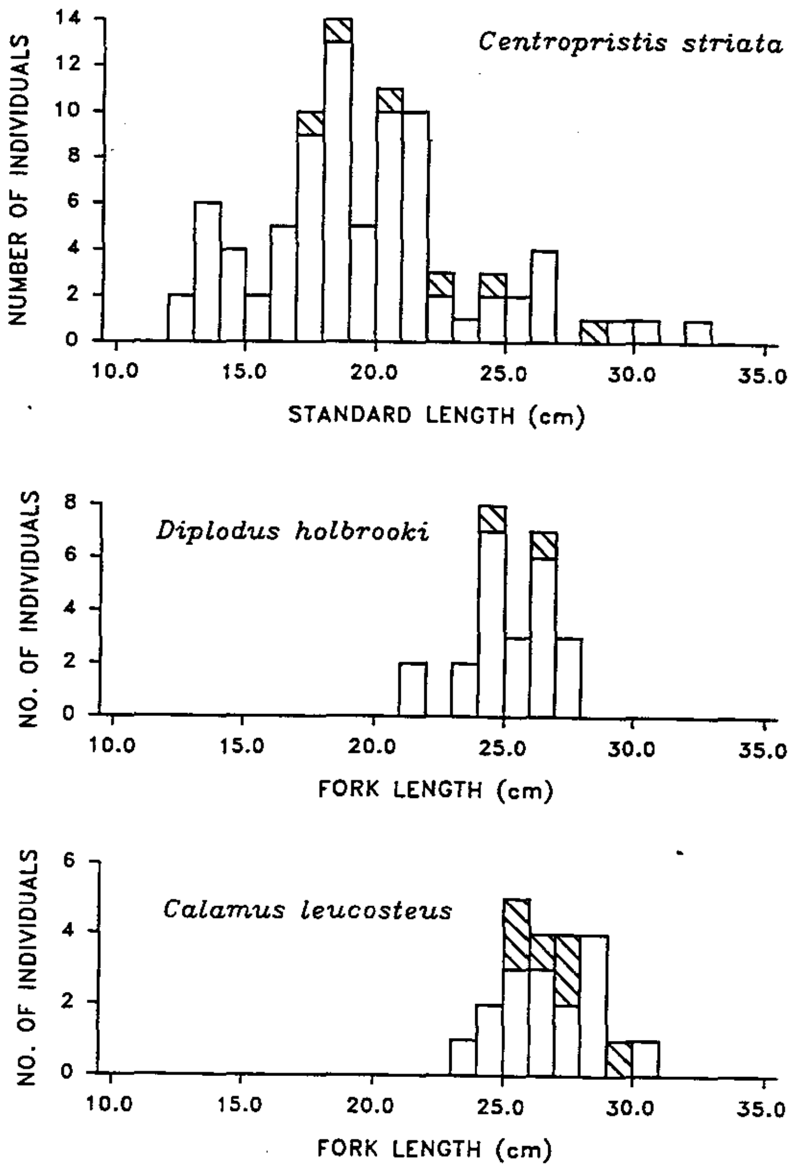

Figure 1. Length frequencies of the three most abundant species of fish held in cages on the bottom for about 24 hr in 21 m depth. Shaded areas indicate mortalities.

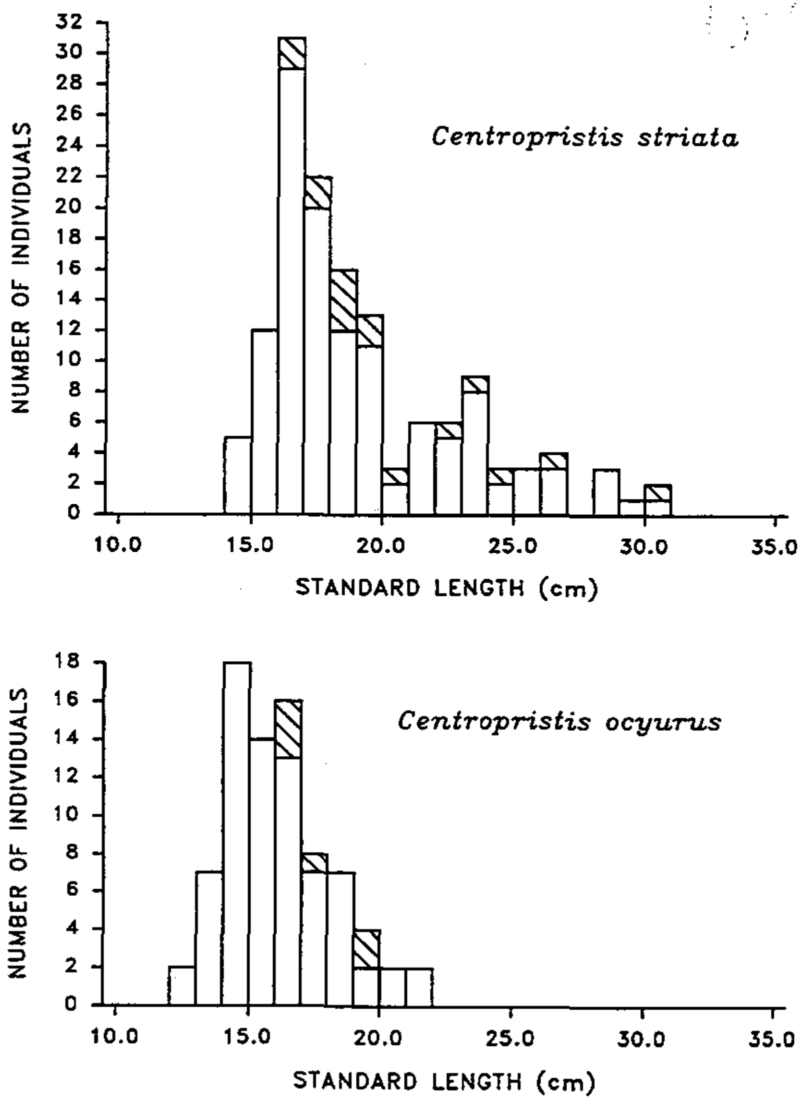

Figure 2. Length frequencies of the two most abundant species of fish held in cages on the bottom for about 24 hr in 36 m depth. Shaded areas indicate mortalities.

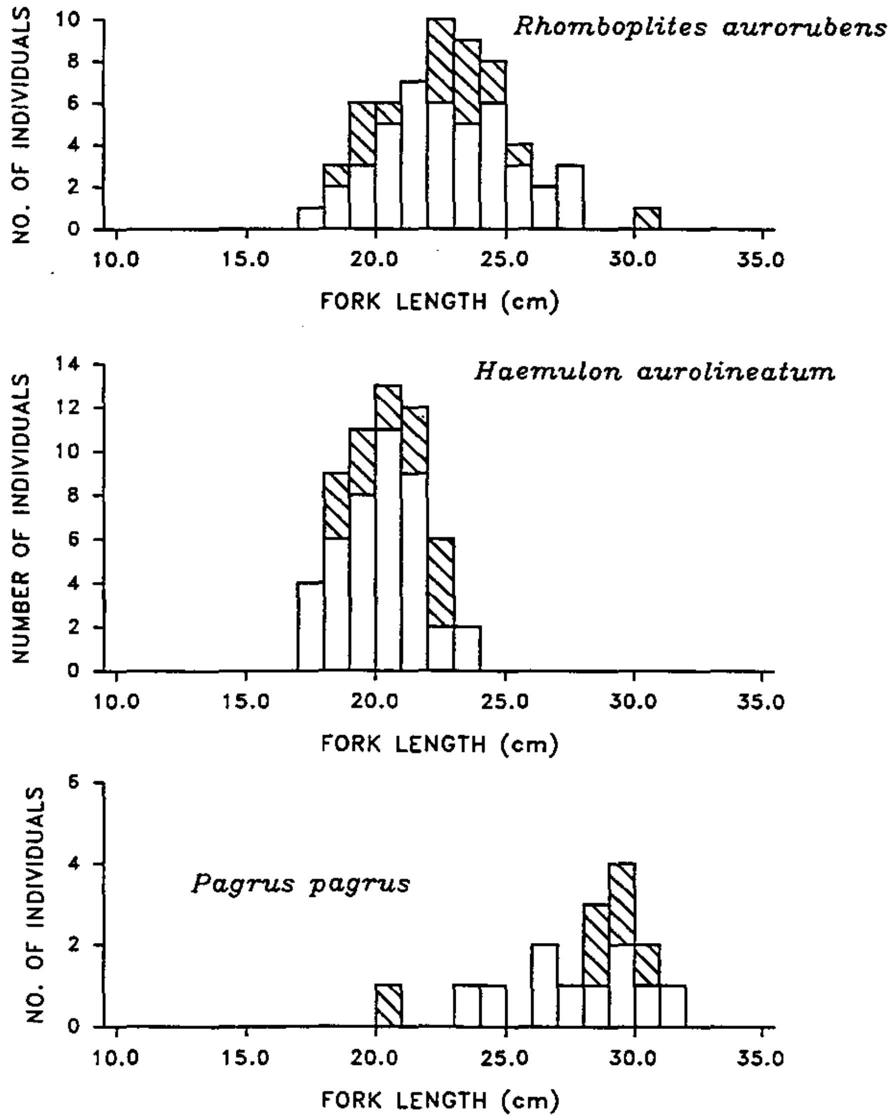

Figure 3. Length frequencies of the three most abundant species of fish held in cages on the bottom for about 24 hr in 46-54 m depth. Shaded areas indicate mortalities.

Gitschlag and Renaud (in press) found that 85% of mortalities occurred during the first day of extended cage trials with the same species. Also, predation may be an important, if geographically variable, factor in survival of released fish. Several attacks by *Sphyraena barracuda* on fish released overboard were observed in the present study, but it was not possible to quantify their effects. During predation trials around oil platforms in the Gulf of Mexico, large predators were nearly absent in one area but were so numerous in another that it was not possible to get hooked fish to the surfaces without it being attacked (Parker, 1991).

Several other variables not considered in this study that may affect survival and should be considered in future attempts to refine survival estimates are: gear type, season, and treatment by anglers. Gear type, especially as it relates to speed of ascent, may be important. Some headboats and commercial vessels use electric reels which bring fish to the surface very quickly, and this rapid ascent may increase mortality due to decompression effects. Mortality may also vary seasonally. Boat decks in summer are sometimes hot enough to cause second degree burns, so it is possible that contact of fish with the deck would be more detrimental in summer than in other seasons. Finally, and most difficult to quantify, the manner in which fish are handeled by anglers during the landing and dehooking process could affect survival. Survival of fish caught by anglers who provide gentle restraint while removing hooks or cutting the line is likely to be greater than that of fish caught by anglers who pin them to the hot deck with their foot while tearing hooks free with pliers.

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